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THE OPERATION OF CANTONMENT WATER-WORKS

By Lieut.-Col. G. A. Johnson

The water-works at the military camps and cantonments are operated under the direction of Col. C. D. Hartman and Lieut.-Col. Geo. A. Johnson, of the Maintenance and Repair Branch of the Construction Division of the Army, commanded by Brig.-Gen. R. C. Marshall, Jr. On August 1, 1918, the Maintenance and Repair Branch issued a series of instructions for the operation and maintenance of the water and sewerage works at these military cities, which has been supplemented from time to time. There is a great dearth of general information on this subject in print. Accordingly permission has been received for the publication in this place of so much of the orders as relate to the management of the water works:

Plans. 1. The Officer in Charge of Utilities should have on file for reference a complete set of plans of the water and sewerage works connected with the camp. Plans of water works owned by municipalities or private water companies which supply the camp should also be on file at the utilities office.

The plans should include:

- Source of water supply,
- Water purification plant,
- Pumping stations and force mains,
- Storage tanks,
- Water distribution system,
- Sewer system,
- Sewage disposal works.

2. These plans should be kept up to date together with all necessary supplementary information.

Records. 1. Records of the operation of all features of the water and sewerage works must be kept in detail. The Officer in Charge and each operator should be provided with a diary in which to record all facts and observations. The diaries should show the number of workmen employed on different branches of the work, orders for supplies and equipment and receipt of same and any unusual conditions as well as regular operating data. All important observations should be recorded, such as odors, flies, fly breeding, unsightly conditions about the plant and any other condition which needs remedying.

2. Complete records should also be kept of all special investigations such as waste of water, leakage from water distribution systems and from plumbing fixtures; tests of pumps and other equipment; and determination of the efficiency of the different parts of the water and sewerage works.

3. All field notes having an important bearing are to be transcribed in regular or special reports made to this office.

Records of population, water consumption and pressure. 1. In addition to the records of operation of the different features of the water works, the following general records are to be kept daily and transmitted to this office once a month.

a. Population, Military and Civilian.

b. Number of Animals.

c. Water Consumption. Total for the day and maximum and minimum rates during the day.

d. Pressure. Maximum, minimum and average at selected high and low points in camp.

GROUND WATER SOURCES

1. Rate of well pumping. Wherever several wells are available water should not be taken at abnormally high rates from any one well, as so doing is liable to result in clogging of the strainers with fine sand. So far as practicable the wells should be operated at a moderate rate and the peak loads taken from suction or storage wells.

2. Observation wells. Two-inch observation wells should be driven at suitable locations in the well field to determine the fluctuations in ground water table.

3. Water depth in wells. The depth in wells where air-lifts are used should be determined weekly to ascertain the submergence of the air nozzle. In some cases this can be done by inserting a pipe of small diameter between the casing and the drop pipe. In case the annular space is insufficient for this a 2-inch observation well should be driven immediately adjacent to the well.

4. Test of pumping equipment. Each well should be tested from time to time to determine the capacity and the efficiency of the pumping equipment. If meters can readily be installed at each well this is the best method. Where this is not feasible, other ways can be found such as measurement of the accumulation in suction or storage wells.

5. Relief of clogged strainers. Where it is found that a well is not delivering the expected volume of water it is an indication that the strainer is partially clogged with sand. Such sand can usually be removed by reversing the flow, under as high a head as can be obtained. In some cases it will be advisable to pump water from other wells, by means of centrifugal or other pumps, through the drop pipe to wash the sand out into the annular space between the drop pipe and casing. In other cases it will be necessary to dismount the pump, remove the drop pipe and bucket the sand out. It is much more economical to keep present wells in first class condition than to be continually driving new ones.

6. Surface flooding of wells in low ground. Where wells are located in low ground liable to be flooded, the tops of the wells should be raised to an elevation above possible high water and the pump house and machinery should be protected against flooding if this is liable to occur.

7. Chlorination of flooded wells. If wells, or the low ground about the wells, should become flooded with polluted water, the wells must not be operated until arrangments have been made to chlorinate the water until all danger is past. This condition is particularly dangerous in the case of shallow wells. Even in the case of deep wells there is danger of the polluted water finding its way into the supply around the outside of the casing or between the casing and the drop pipe.

8. Guard well fields, tanks and pumping stations. The well-field, particularly in the case of unsealed wells, suction or storage tank and pumping stations, should be carefully guarded to protect the supply from accidental or wilful contamination. The actions of men working at or near the source of supply should be carefully watched.

9. Chemical and bacterial tests. Chemical and bacterial tests of the water should be made daily, or with sufficient frequency to show the character of the water at all times. Where treatment is required, such treatment must be subject to laboratory control.

Where chlorination or filtration is required, tests must be made at least daily of the raw water, treated water, and tap water.

10. Daily records. Daily records are to be kept of the quantity of water pumped, the operation of the pumps, power used, repairs made, work done on wells and all other operating facts, observations, and tests.

SURFACE WATER SOURCES

1. Rainfall and run-off data. In the case of surface water supplies it will be important to secure rainfall and run-off data, particularly in the case of limited supplies, to determine the available quantity and the adequacy of the supply.

2. Watershed policed. Even though the water supply be treated with chlorine or filtered, a reasonable amount of policing of the watershed is necessary to prevent undue pollution. Reservoirs, dams, gate-houses, etc., must be properly guarded.

3. Intake racks and screens kept clear. Racks and screens at the intake must be kept clear. Racks can generally be taken care of by rakes or squeegees, but screens should be removed alternately and occasionally scrubbed. Protection against excessive clogging of racks and screens can be secured by the use of a floating boom arranged like a scum board several feet, in front of the rack or screen.

4. Analytical control. Chemical, bacterial and microscopical analyses of the raw, treated and tap water should be made daily, or with sufficient frequency to show the character and quality of the water at all times. Wherever chlorination or filtration plants are provided, they must be operated under chemical and bacterial control.

5. Algae growths in reservoirs. Objectionable growths such as algae may produce offensive tastes or odors in surface waters, particularly when stored in large reservoirs. Copper sulphate properly applied is effective in checking or reducing such conditions. Explicit instructions will always be furnished by the Washington office before this treatment shall be put into effect.

6. Records. Records are to be kept every day of all operations, repairs, measurements, observations and tests, as well as the results of the laboratory tests.

CHLORINATION PLANT

1. Instructions for operating chlorinators. Manufacturers' instructions for operating chlorination apparatus should always be available to the operator who should become thoroughly familiar with its mechanism and competent to adjust and repair it if necessary.

2. Preliminary precautions. In order to prevent possible clogging of the regulating valve at the top of the chlorine cylinder with oil or other impurities, this should be taken into the open air and the valve turned sufficiently to blow off a little gas. When doing this care should be taken to stand on the windward side and avoid inhaling the gas.

3. Weighing the chlorine. The liquid chlorine cylinders should be set on platform scales and the automatic apparatus checked up frequently to assure proper dosing.

4. Reserve supply of chlorine. An ample supply of the sterilizing agent should be kept on hand to tide over any delays in shipment or in transit, and empty cylinders must be returned promptly.

5. Duplicate apparatus. When used constantly, duplicate apparatus should be available and in proper working order, and all necessary repair parts should be kept on hand.

6. Analytical control. This treatment should be subject to laboratory control, and bacterial tests should be made with sufficient frequency to ensure adequate and economical use of the sterilizing agents.

7. Records. Records are to be kept daily of the volume of water treated, the rate of application of the chemical, bacterial results on the raw water, treated and tap water, and all other operating facts and observations.

FILTRATION PLANT

1. General operators. No attempt will here be made to explain all of the operations incident to the coagulation and filtration of water, water softening or iron removal. An experienced operator is to have supervision of each plant, whether owned by the government or by a municipality or by a private company. Furthermore, when any doubt arises regarding any detail of operation or results the Washington office must be notified promptly, and advice will be immediately forthcoming.

2. Improvements and enlargements. Where any part of the plant is found to be incapable of doing its work properly so as to insure a water supply adequate in quantity and satisfactory in quality, notation as to the character of the deficiency and apparent possible remedy should be transmitted to this office, where such recommendations will be given due consideration and such improvements or enlargements, as the case may require, will be authorized.

3. Records. Among the records which are to be kept at the filtration plant are the following:

a. Turbidity, color, alkalinity and bacterial content of raw water.

b. Kinds and amounts of chemicals used.

c. Number of filters in service and length of runs.

d. Quantity of water filtered.

e. Filter units washed and quantity of wash water used, time of application of water and of air.

f. Total bacteria and B. coli in raw, filtered and tap water.

g. Labor employed.

h. All other operating facts and observations.

PUMPING STATIONS

1. Isolation of fire risks. The general instructions which have already been issued with respect to keeping fire-risks from proximity to pumping stations, wooden storage tanks, etc., should be rigidly enforced. In case the fire hazard at a pumping station is especially serious the type of construction known as "slow burning" should be provided.

2. Guard pumping stations. Pumping Stations should be under guard at all times.

3. Pump operating troubles. It is not feasible to go into all of the operating troubles of the various types of pumps used at water works, but some of the principal troubles are discussed below.

a. Deep well pumps. With deep well pumps, troubles are experienced from sand or other substances getting between the ball or conical valve and the valve seat, the wearing out of the sucker rods from binding on the side in the case of crooked wells, and the wearing out of bearings, particularly on unbalanced, single-acting pumps. Sand can generally be removed by operating the pumps at high speed aided in some cases by quickly increasing and decreasing the pressure. If this be not successful, it will be necessary to remove the working barrel and sucker rods. This should be done occasionally in any event, and provision should be made in the well house for its easy accomplishment. The wearing out of sucker rods caused by rubbing on the side of the well casing frequently can not be corrected, and if the difficulty is serious either through continual replacement of rods or power loss it may be more economical to discontinue the well.

b. Impeller pumps. Impeller pump troubles are due largely to wearing out of bearings and the wearing of casings by runners because of improper adjustment or the wearing of alignment bearings. Oiling, also, particularly with the American well type, sometimes gets out of order. In any case the only remedy is the replacement of the worn parts.

c. Centrifugal pumps. Centrifugal pumps are generally reliable, and get out of order mostly because of poor adjustment of the runner due to the balancing devices not taking proper care of the thrust and allowing the runner to rub on the casing. The proper adjustment of the runners within the casing is very important.

d. Air lifts. Air lift devices are extremely simple but require much care in adjustment of air piping and nozzle to the size of well, depth of water and quantity to be pumped. These matters must be taken care of by a man experienced in this class of work, and frequent observations of water level must be made to secure proper adjustment.

4. Repair shop. A well-equipped repair shop or workroom with a competent machinist should be available at every important pumping station in order to maintain the machinery in proper working order. Duplicate parts should always be kept on hand.

5. Machinery replacements. It is likely that because of the impossibility of obtaining machinery exactly fitted in all cases to the requirements, some of the machinery installed might economically be replaced by more efficient apparatus. Efficiency tests will determine the facts, and any request for replacements should be accompanied by the results of such tests.

6. Use oil engines daily. Where gasoline or oil engines are used for auxiliary power, they should be tested daily. The following instructions shall be posted in each pumping station in which there is an oil, gasoline or kerosene unit:

Daily tests of at least ten minutes duration shall be made of all fire pumps operated by oil, gasoline and kerosene engines. During tests pumps shall be operated at rated speed and full fire pressure maintained.

Motor should be started slowly and note made whether there is any trouble in this operation.

Motor should then be brought up to speed and note made of any uneven explosions, unusual noises, etc.

Records shall be made of (a) duration of test; (b) pressure maintained; (c) remarks as to defects if any, and (d) name of operator.

Under "Remarks" shall be noted:

Defect in ignition, starting, oiling system and gas supply.

Amount of gasoline on hand.

Are cocks on gasoline supply line open?

Condition of lubricating oil supply.

Whether oil feed is working properly.

Date batteres last recharged.

Whether gate valves on suction and discharge pipe are in good working order.

7. Layout maps. In each pumping station there should be hung on the wall a blueprint showing all pipe connections, valves, pump locations, etc., in or about the station. Whenever changes in piping are made the map should be revised to show such changes.

8. Records. The daily record should show the rate of pumping, pressure, units in service, repairs made, power used, amount of fuel on hand and amount used for different purposes, and all other operating facts and observations.

FIRE HYDRANTS

1. Paint fire hydrants. Fire hydrants should be made as conspicuous as possible by painting bright red.

2. Inspection of hydrants. Hydrants should be inspected frequently to see that they are in good working order with the caps in place and not screwed on too tight.

3. Protection of hydrants against injury. Any hydrants so located as to be in danger of injury from traffic or other cause should be adequately protected by guard posts or railings.

4. Pipe branches for fire hydrants. Four (4) inch pipe should be used for hydrant branches only up to thirty (30) inches in length. When branches longer than 30 inches are necessary six (6) inch branches and pipe should be used and the hydrant set on a 6 inch by 4 inch Redwood large end bell.

5. Hydrant number. Each hydrant shall have a number which shall be painted on the barrel. Figures should be at least three inches in height. Location of hydrants by number shall be shown clearly on a map. This map shall be kept up to date, and all additions, changes or repairs shall be reported by number. Copies of this map should be on file at the various offices concerned in the operation of the water works and the matter of fire protection.

STORAGE TANKS

1. Storage tanks covered. Elevated storage tanks and reservoirs should be covered with a substantial roof and all openings for ventilation should be properly screened to prevent the access of birds and insects. Manhole covers should be kept closed and locked.

2. Guard tanks by fencing. Where such tanks or reservoirs are accessible they should be fenced in to keep out all persons not duly authorized on the premises.

3. Fill tanks at times of low draught. Storage tanks or reservoirs should be filled at times of low draught and not by extraordinary pumping at times of maximum consumption; and peak loads should as a rule be taken from storage.

4. Tanks guarded and inspected. Storage tanks and reservoirs should receive frequent inspection, and in the majority of cases should be under guard. Particular attention should be given to wooden tanks liable to be set on fire by railroad locomotives.

5. Automatic recording devices. Height of water gauges with automatic recording devices should be installed so that records of the daily fluctuations in volume of water in storage may be available. Such records are of value particularly in indicating the efficiency of operation and in computing water consumption.

DISTRIBUTION SYSTEM

1. Pressure reduction prohibited. Reduction in pressure on the distribution system by cutting storage tanks out of service, by the use of pressure reducing valves, by partially closing valves or other means, will not be permitted without special authorization from this office. If local conditions appear to demand a departure from this policy a description of conditions is to be submitted for an investigation.

2. Cover over pipe lines. All pipe lines and service pipes should have sufficient earth cover to protect them from freezing. If necessary, pipes should be lowered or additional cover provided. Risers to elevated tanks should be protected with pipe frost proofing if necessary. Sawdust is not suitable because it becomes saturated with moisture and freezes.

3. Inspections. Frequent inspection of the distribution system should be made to maintain all valves in good operating condition, especially those depended upon for use in event of fire.

4. Pipe location maps. A map showing the location of pipes and valves should be accessible to all operators, and all valves which are not standard opening should be shown conspicuous on this map. Any valves temporarily closed to improve service should be so indicated on the map by special push pins.

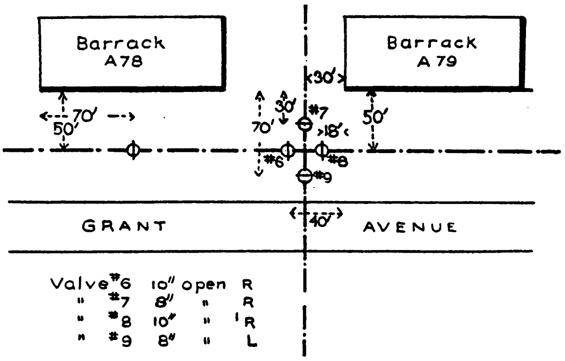

FIG. 1. METHOD OF REFERENCING VALVES

5. Air valve inspection. Air valves along force mains or gravity supply lines should be inspected at least weekly and opened slightly to relieve air in case the valve is stuck.

6. Records. Records should be kept of all observations, repairs, changes, etc., on the distribution system.

7. Gate valve reference book. The location of all gate valves on the distribution system should be determined and shown in a reference book. The usefulness of such a book is obvious. The valves should be located and tied into permanent land marks such as barrack buildings, etc. The measurements from these land marks should be carefully made and entered on a sketch similar to the sample attached. These sketches should be indexed and bound together to make a reference book. Care should be used in determining whether or not a valve is right or left hand. A valve which opens by turning in the direction the hands on a watch travel, opens to the right and should be indicated "R."

8. Tracings of these sketches should be made and retained as part of the Utilities Records. Blue printed copies on linen should be a part of the Water Works Repair Gang's equipment. A copy should also be on file in Washington.

9. In connection with this Reference Book, a master map of the entire distribution system on a small scale should be prepared, on which valve locations as shown on the sketches would be indexed.

PREVENTION OF LEAKAGE AND WASTE

1. Clothes washing under running water. The washing of clothes under showers or running streams of water results in unnecessary waste. Where feasible, set or movable tubs should be provided for this purpose. In some cases it will prove advantageous to provide a water connection and sink outside the latrine.

2. Overflow of troughs. Water troughs and tanks at Remount Stations should not be permitted to overflow, not only because of unnecessary waste of water, but also because mud about the trough is objectionable.

3. Devices to reduce pressure locally. The use of such devices as perforated lead washers, slugs, and marbles in the faucets and shower sprinkle heads for the purpose of locally reducing excessive pressure and resultant waste, is recommended. Round-headed, self-closing faucets can be advantageously installed where there is a scarcity of water.

4. Regulation to prevent waste of water. Regulations should be issued to prevent unnecessary use of water in latrines, the leaving of faucets and shower heads open after using, etc., and should be rigidly enforced by inspection and policing if necessary.

5. Water waste surveys. Systematic surveys should be made from time to time to locate leaks in water mains and service pipes. Tests for leakage on main lines can be made by pitometer readings, by the use of aquaphones, and by pressure gauges in isolated districts supplied by small pipe lines. Aquaphone tests should be made when the pressure is high, as the sound from leaks will be greater at such times. Localization of waste with master meters can best be made during the hours of minimum consumption, from midnight to 4 a.m. The flow in sewers may also serve as an indication of water waste or leakage in different localities.

The method of making a water waste survey best adapted to the conditions encountered in camps and cantonments is known as the hose and meter method. The survey may be carried on by this method with the least amount of labor and does not require the services of technically trained men.

Apparatus. The apparatus necessary in making hose and meter tests is: One 2-in. compound type water meter, with fish trap or screen attachment. Pressure gauge attached to hydrant nozzle cap. Aquaphones and fire hose as needed.

Hours for making tests. In order that accurate figures be obtained it is necessary that tests be made when all legitimate consumption is at a minimum. For this reason tests must be made at night, preferably between the hours of midnight and 4 a.m.

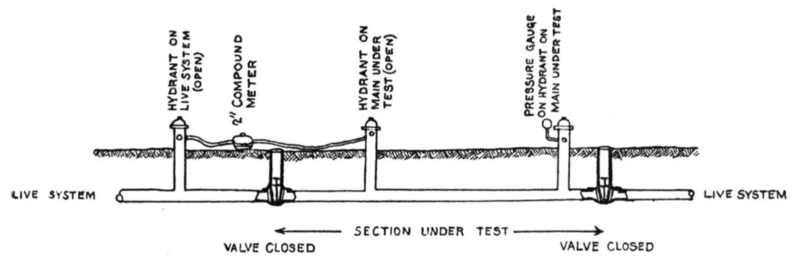
HYDRANT ON LIVE SYSTEM (OPEN)
2" COMPOUND METER
HYDRANT ON MAIN UNDER TEST (OPEN)
PRESSURE GAUGE ON HYDRANT ON MAIN UNDER TEST
LIVE SYSTEM
LIVE SYSTEM
SECTION UNDER TEST
VALVE CLOSED
VALVE CLOSED

Fig. 2. Hose-and-Meter Test for Leakage

Isolating the test section. The section to be tested is isolated from the remainder of the system by closing gate valves on the main. These valves should be tested to assure tightness. The accuracy of the test depends on the tightness of the valves isolating the test section. If a leaky valve is encountered it will be necessary to drop back to a valve that is tight.

Setting the meter. The isolated section is connected to the live system by fire hose laid from a hydrant inside the test section to a hydrant outside on the live system. The meter is set on this line of hose. All water consumed by the isolated section must now pass through the fire hose and meter when the hydrants are opened. The meter being of the compound type will automatically and accurately measure both large and small flows.

Hydrants to be flushed. Hydrants should be well flushed before using in order to remove any sticks or stones which may be lodged in the hydrant branches. Care should be taken in joining hose to guard against dirt and stones being admitted to the meter.

Pressure records. A pressure gauge should be attached to a hydrant nearby the testing station in order that record may be kept of the pressure on the section under test. A pressure equivalent to that ordinarily in the system should be maintained throughout the test.

Key map. Before actual tests are begun a map should be prepared showing clearly the division of the distribution system into permanent test sections. Permanent test stations for the indicated sections should be established and given a distinguishing symbol on the map.

Reporting results. Monthly reports are to be made which will describe in detail the progress of the survey. The report covering the first month's work must include the map showing how the distribution system has been sectionalized. A tabulated form of report will be used in conjunction with the written report.

Sub-division tests. When a section is located that demands furthur investigation to localize a flow that is abnormal a sub-division test should be made. That is, the large test section is in turn divided into smaller sections which are tested individually in order that the flow indicated for the large test section may be localized on a short run of main for final analysis and location.

Reports of sub-division tests. Individual tabulated reports should be made of sections in which sub-division tests are made.

6. *Night inspections.* Faucets, showers, toilets, etc., should be inspected every night, and when found out of order should be repaired or replaced promptly.

7. *Records.* Complete records should be kept of all observations and investigations relating to water waste and leakage.

ELECTRIC PIPE THAWING

Thawing of water pipes with electric current is now an accepted practice.

An outfit to take care of this work should be a part of the utilities equipment in camps located in that part of the country where frozen service pipes and mains constitute part of the operating difficulties.

An outfit which contains only materials readily obtained at the least possible expense and the component parts of which may be readily converted to other uses, is to be desired.

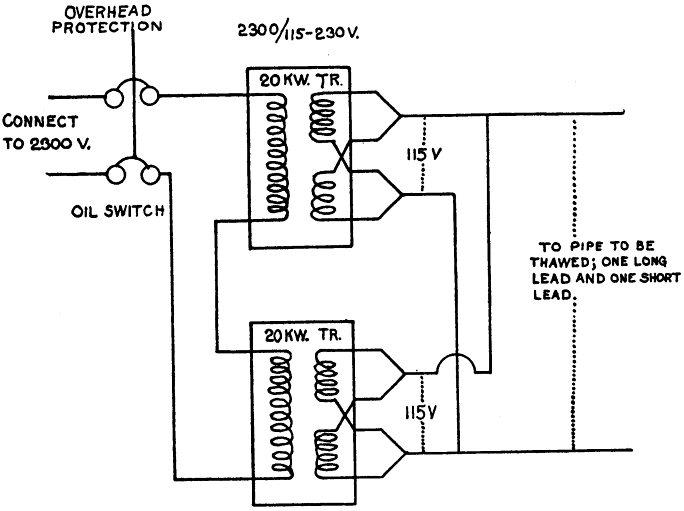

FIG. 3. CONNECTIONS FOR ELECTRIC THAWING

For that reason, the enclosed plan is submitted. The equipment required to make up a thawing outfit according to the plan attached is as follows:

300 feet no. 6 D. B. R. C. Stranded Cable 5000 Volt Insulation.
500 feet no. 00 D. B. R. C. Stranded Cable 500 Volt Insulation.
2-20 KVA 2200/220/110 Volt 60 Cycle distributing transformers.
1-2 Pole S. T. 2500 Volt outdoor type 100 Amp. oil switch with overload trip.

It is thought that most camps will have the majority of these parts in stock. If this is not the case, requisitions should be submitted promptly for such equipment as is necessary to assemble an outfit of this type.